R E P O R T   R E S U M E S

ED 016 060 VT 002 301

OCCUPATIONAL CRITERIA AND PREPARATORY CURRICULUM PATTERNS IN TECHNICAL EDUCATION PROGRAMS. AREA VOCATIONAL EDUCATION PROGRAM SERIES, NUMBER 4.

BY- RONEY, MAURICE W.
OFFICE OF EDUCATION (DHEW), WASHINGTON, D.C.

REPORT NUMBER OE-80015 PUB DATE 65
REPORT NUMBER VOCAT-DIV-BULL-296
EDRS PRICE MF-$0.25 HC NOT AVAILABLE FROM EDRS. 33P.

DESCRIPTORS- *TECHNICAL EDUCATION, CRITERIA, PROGRAM PLANNING, *PROGRAM DEVELOPMENT, PROGRAM GUIDES, JOB ANALYSIS, CURRICULUM PLANNING, *EDUCATIONAL NEEDS, *TECHNICAL OCCUPATIONS, ABILITY, *EMPLOYMENT QUALIFICATIONS, CURRICULUM,

A REFERENCE BASE OF GENERAL ABILITIES DESIGNED TO IDENTIFY TECHNICIAN OCCUPATIONAL REQUIREMENTS WHICH CAN BE TRANSLATED INTO EDUCATIONAL PROGRAM CONTENT INCLUDES (1) A FACILITY WITH MATHEMATICS WITH THE ABILITY TO USE ALGEBRA AND TRIGONOMETRY AS TOOLS IN THE DEVELOPMENT OF IDEAS THAT MAKE USE OF SCIENTIFIC AND ENGINEERING PRINCIPLES, (2) A PROFICIENCY IN THE APPLICATION OF PHYSICAL SCIENCE PRINCIPLES, (3) AN UNDERSTANDING OF THE MATERIALS AND PROCESSES COMMONLY USED IN THE TECHNOLOGY, (4) AN EXTENSIVE KNOWLEDGE OF A FIELD OF SPECIALIZATION WITH AN UNDERSTANDING OF THE ENGINEERING AND SCIENTIFIC ACTIVITIES THAT DISTINGUISH THE TECHNOLOGY OF THE FIELD, AND (5) COMMUNICATION SKILLS THAT INCLUDE THE ABILITY TO INTERPRET, ANALYZE, AND TRANSMIT FACTS AND IDEAS GRAPHICALLY, ORALLY, AND IN WRITING. WITH THESE FIVE UNDERLYING GENERAL ABILITIES AS UNIVERSAL REQUIREMENTS, 12 CRITERIA WERE DEVELOPED FOR IDENTIFYING SPECIFIC OCCUPATIONS WHICH REQUIRE TECHNICAL EDUCATION. THE CRITERIA USED TO ESTABLISH THE LEVEL OF COMPETENCE IN THESE OCCUPATIONS CONSTITUTE AN EDUCATIONAL STANDARD. BY THIS STANDARD, THE TECHNICIAN SHOULD HAVE AN EDUCATIONAL BACKGROUND EQUIVALENT TO THAT OBTAINED IN A PROGRAM OF AT LEAST 1,800 HOURS OF INSTRUCTION WITH A PATTERN OF COURSE WORK THAT CORRELATES MATHEMATICS AND PHYSICAL SCIENCE WITH TECHNICAL STUDY. A STUDY OF CATALOGS OF 25 INSTITUTIONS SHOWS THE ORGANIZATIONAL PATTERNS OF 2-YEAR POST-HIGH SCHOOL TECHNICAL PROGRAMS, AND AN APPENDIX ILLUSTRATES THE DIVISION OF SUBJECT MATTER IN A 3-YEAR TECHNICAL CURRICULUM OFFERED AT THE SECONDARY SCHOOL LEVEL. THIS DOCUMENT IS AVAILABLE AS FS 5.280--80015 FOR 15 CENTS FROM SUPERINTENDENT OF DOCUMENTS, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C. 20402. (HC)

OE-80015

Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
Office of Education

OE-80015
Vocational Division Bulletin No. 296
Area Vocational Education Program Series No. 4

Occupational Criteria and Preparatory Curriculum Patterns in

TECHNICAL EDUCATION PROGRAMS

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Abraham Ribicoff, *Secretary*

Office of Education
Sterling M. McMurrin, *Commissioner*

Foreword

OCCUPATIONAL PATTERNS in industry have changed significantly in the past two decades, and the rate of change is increasing. New materials, new processes, automation, and improved techniques of measurement and control have combined to increase the need for technically competent persons with special abilities who can support and supplement the efforts of engineers and scientists throughout the technological complex.

The need for technically competent persons can be met by expanded educational services. Preparatory and extension programs to meet this need are being developed in a variety of institutions and at several grade levels in technical and comprehensive high schools, junior colleges, private and public technical institutes, and in area vocational-technical schools.

As these educational services expand, there is an increasing need for qualitative standards. It is only through widespread understanding of purpose that these standards of quality can be attained.

The development of technical education programs is a clear-cut responsibility of vocational education under the provisions of the National Defense Education Act of 1958. Specifically, Title VIII of this act provides assistance to the States for developing and expanding vocational education programs to train youth and adults for "useful employment as highly skilled technicians in recognized occupations requiring scientific knowledge." The training requirements for these occupations are unique in many respects; the criteria developed to identify these occupations early in the program have been sharpened and defined. Experience has revealed a need for a better understanding of the functions of technically competent personnel, their educational needs, and the role of public vocational education in providing appropriate training programs.

This publication has been prepared to provide a better understanding of these factors by utilizing the results of research and investigation specifically keyed to the preparation of personnel for occupations which require extensive technical training. It is designed to serve as

a guide for persons on both State and local levels who are concerned with the establishment, administration, supervision, and operation of preparatory programs. While written primarily from the standpoint of the 2-year post secondary school preparatory program and the occupations for which such programs are designed, the educational concepts represented are common to all high-quality technical instruction. Therefore, this bulletin can also be of value in determining requirements for effective extension programs, using the methods and procedures described in the Office of Education publication OE 80C10, *Determining Requirements for Development of Technical Abilities Through Extension Courses.*

In addition, this publication should be useful in designing and conducting surveys of industrial training needs, in program planning, in teacher education, and in public relations work. It provides a reference for both planning and evaluation—a reference based on analyses and interpretations of the work that has been done over the years in developing and perfecting programs of technical education. It was prepared by Maurice W. Roney, program specialist in area vocational education, assisted by the staff of the Area Vocational Education Branch. Valuable contributions were made by professional organizations and individuals through reviewing draft materials and suggesting improvements.

W. M. Arnold
Assistant Commissioner
for Vocational Education

Contents

I. The Problem of Identification

THE PLANNING AND DEVELOPMENT of technical educational programs to meet the objectives of Title VIII of the National Defense Education Act have focused attention on the need for clearly defined occupational and educational criteria. To determine the most effective means of developing technical education programs Federal, State, and local administrators of vocational education need information as to the functions and the educational requirements of the occupations under consideration.

Several attempts have been made to define the term "technician." From the definitions used at various times and for various purposes, it has become apparent that the term is generic. Qualifying modifiers such as "highly skilled," "engineering," "industrial," and others add meaning to the term only as they become established and accepted through usage. Apart from job titles and the terms used to define or describe these titles, there is need for uniformly acceptable, clearly defined criteria to identify the functions of "technician" within a wide range of occupations.

Research design and development technicians work in direct support of engineers and scientists, performing tasks that are functional parts of scientific and engineering activities. Also, personnel with engineering-related ability and understanding are engaged in other activities such as production planning and control, technical sales, and field consultative service. For occupational criteria to be of maximum value in planning technical education programs, they must be based on the knowledge and ability requirements of such occupations.

Technical education must also develop a uniformity of purpose if it is to become clearly identified as a part of the educational system. Educational criteria developed from the basic requirements of specific occupations are urgently needed. Although the use of criteria may appear to be suggestive of standardization and may produce an unfavorable reaction in an educational context, standardization is not an inevitable consequence of the acceptance and use of educational criteria. What is needed in technical education is not so much a standard curriculum as a curriculum standard. The hazard that appears

to be most significant is overdiversification, not uniformity. Diversification in education is commendable, but it should not be used as an excuse for programs that are inadequate in terms of good educational practices.

Technical education, in the present concept of these services, is a relatively new phenomenon in public education. There are few well established landmarks that will serve as guides for developing new programs in this field. Excellent technical programs have been offered by a few public and private institutions throughout the United States for many years; e.g., technical institutes. In general, however, public institutions operate under conditions that are sufficiently different from these established special-purpose schools to preclude any wholesale transplantation of curriculums and instructional processes. A need exists for educational criteria that will distinguish the form and function of technical education apart from the institutional setting in which it is offered.

Two factors combine to complicate the process of identifying the occupational functions and educational needs of "highly skilled technicians in recognized occupations." One is the rapid expansion of the technologies, with the confusion of terminology and job classifications that has resulted. The second is the inordinate range of educational programs that have as their stated objective the training of "technicians."

Occupational surveys, education-industry conferences, and consultative services have been used in attempts to identify the work functions and the training needs of the "technician." Much of the work done by engineering and technical societies, such as the American Society for Engineering Education, in the field of engineering technician training has been valuable in the identification process. There remains, however, a need for a more precise analysis of the relation between the function of the "technician" and the education that can most effectively meet those requirements.

The central concern of technical education is with a body of knowledge rather than with specific jobs. In the interest of clarity, the term "technician" in this document refers to scope of training and work capability, rather than to employment classification as such, and to job requirements calling for broad technical competence based on proficiency in the application of mathematics and physical science principles and extensive knowledge in technology. The following sections will develop a basis for the identification of such technicians.

II. Analyzing Requirements

VOCATIONAL EDUCATION has traditionally made use of certain techniques to insure the effectiveness of training programs. Two of these techniques are the occupational survey to determine training needs and the job analysis to determine curriculum content.

Surveys designed to determine the needs of technicians *per se* are not always adequate as a means of identifying the educational services required. A local survey may give a false concept of the national need. An even more serious weakness may be the lack of specific criteria that identify the techinician in terms of the range and depth of technical knowledge needed for his work.

The job analysis, when used to identify technical training needs, also has limitations. The work of the technician does not always follow a definite cycle, but instead may vary from day to day and from one project to another. Hence, the work does not always lend itself to job analysis techniques that attempt to identify a fixed list of job functions which, in turn, can be translated into a list of instructional topics. For example, a job analysis might lead to the conclusion that proficiency in mathematics would not be required in the training program because the duties of the occupation did not include mathematical calculations. Such a conclusion overlooks the need for mathematics as a learning and communication tool and can adversely influence curriculum and course design.

The effect of surveys and analyses that have limitations of this nature can be to undervalue the level of scientific and technical ability required for the occupations, and consequently can lead to a misdirection of training program objectives.

In developing the criteria suggested in this document, two basic assumptions were made: one, that the technical occupations, whether or not they are closely related to engineering functions, require broad technical competence based on a knowledge of engineering and scientific principles; second, that a significant part of this knowledge can best be provided by formal systematic training in organized programs of instruction. Proceeding from these premises, two references were developed; one to identify the occupations that require technical training and the other to be used in designing training programs.

The first attempt by the U.S. Office of Education to identify technicians led to the development of a tentative list of certain functions and activities that require the application of technical knowledge. To test their validity and usefulness these criteria were applied to a number of occupations throughout the country. Certain inherent weaknesses appeared regularly where the criteria were used as a checklist to select occupations for which technical training programs could be established. It became evident that much of the technician's responsiblity could not be expressed in terms of specific day-to-day functions or job titles. A significant part of the technician's responsibilities involves judgment and decision-making ability and requires broad technical concepts closely paralleling those of professional engineers and scientists working in the same general occupational areas.

The second stage in the development of occupational criteria was to determine, as objectively as possible, the abilities of technicians that are inherent in their job functions—those attributes that provide a basis for making decisions. Sources of this information were follow-up studies of technicial institute graduates, advisory committee recommendations, consultative services, and manpower study reports prepared by various government agencies such as the Bureau of Labor Statistics, the Bureau of Employment Security of the U.S. Department of Labor, and the National Science Foundation.

From the information obtained through continued study and analysis, the occupational criteria have been restated and further defined.

In addition, five general abilities were considered to be universal requirements for technician occupations. Using these five abilities as a minimum or background requirement, it is possible to achieve a degree of uniformity and consistency in applying the criteria.

To provide a guide for the development of certain types of preparatory programs, an analysis was made to determine the patterns of orgainzation in preparatory educational programs that have as their objective the training of technicians. For this analysis, 25 schools were selected on the basis of their established success in the training of technicians. Technical institutes, both public and private, junior and community colleges, and 4-year colleges and universities were represented. Two-year post high school preparatory curriculums in mechanical, electrical, and electronic technologies were chosen as a base for the analysis. It should be recognized that equivalent technical education may be obtained through means other than the full-time preparatory programs analyzed in this study.

Finally, the results of the curriculum study are compared with the occupational criteria, and suggestions are made as to some of the ways in which these criteria may be used to promote and develop educational programs in the technologies.

III. Occupational Requirements

THE OCCUPATIONAL CRITERIA that are set forth herein were developed to serve as a guide in instructional program development. To be useful for this purpose they must be interpreted carefully and in an educational context. They are not designed to be used for job classification purposes, and no reference is made to job titles. In the course of developing these criteria it became evident that, if they are to be consistent, a somewhat arbitrarily chosen set of technical abilities common to technician occupations must be understood and accepted. Unless this is done there is no reference base for the criteria—no real basis for determining the common requirements of technical occupations which can be translated into effective educational programs.

Accordingly, a set of general requirements for these occupations has been developed. They are essentially universal, in that they represent abilities rather than specific functions and, as will be shown in the following section of this document, form the basis for educational programs in technology.

General abilities

1. Facility with mathematics; ability to use algebra and trigonometry as tools in the development of ideas that make use of scientific and engineering principles; an understanding of, though not necessarily facility with, higher mathematics through analytical geometry, calculus, and differential equations, according to the requirements of the technology.
2. Proficiency in the application of physical science principles, including the basic concepts and laws of physics and chemistry that are pertinent to the individual's field of technology.
3. An understanding of the materials and processes commonly used in the technology.
4. An extensive knowledge of a field of specialization with an understanding of the engineering and scientific activities that distinguish the technology of the field. The degree of competency and the depth of understanding should be sufficient to enable the individual to do such work as detail design using established design procedures.
5. Communication skills that include the ability to interpret, analyze, and transmit facts and ideas graphically, orally, and in writing.

It is recognized that certain personal characteristics are also desirable in these occupations; that much of the technician's work requires an understanding of social and economic factors, a good knowledge of industrial organization, and acceptable personal attitudes. In developing criteria for identification purposes, however, it was considered advisable to use the more impersonal characteristics of the technician's work in order to obtain maximum objectivity.

With the five underlying general abilities as universal requirements, 12 criteria for technician occupations were developed. Some of these criteria are broadly inclusive, while others describe specific functions. In applying each criterion the five general abilities must be considered basic and corporate. *No single criterion can be considered as definitive unless the level of competence being exercized is within the framework established by these five ability requirements.*

The 12 criteria are not to be given equal weight in identifying occupations, and no single occupation would require all of them. Representative local advisory groups can be helpful in further defining and weighing these criteria in specific occupations.

Criteria for identifying occupations that require technical education

The individual in the occupation:

1. *Applies knowledge of science and mathematics extensively in rendering direct technical assistance to scientists or engineers engaged in scientific research and experimentation.*

Scientific research and experimentation require technical services in such fields as chemistry, physics, metallurgy, electronics, and nucleonics. The technician in these activities usually works closely with an engineer or scientist and is required to use his knowledge of scientific principles and mathematics almost constantly in his work.

2. *Designs, develops, or plans modifications of new products and processes under the supervision of engineering personnel in applied engineering research, design, and development.*

Research and design activities utilize technical personnel at several levels. The technician occupations in this setting are comparatively well identified. They involve significant responsibilities for the design, planning, and development of new products and processes, and for laboratory testing and reporting functions.

3. *Plans and inspects the installation of complex equipment and control systems.*

Planning and estimating technical equipment installations are functions that require broad-range abilities involving practical design and modification. Missile systems, industrial process control instrumentation, and automatic line production systems are representative of these activities.

4. *Advises regarding the maintenance and repair of complex equipment with extensive control systems.*

The maintenance of intricate and complex equipment requires a knowledge of systems or combinations of systems—mechanical, electrical, electronic, hydraulic, pneumatic—in industrial production equipment, electronic computers, telemetering equipment, and aircraft ground control equipment. Technicians with advisory responsibilities should have a wide range of practical experience in addition to technical training.

5. *Plans production as a member of the management unit responsible for efficient use of manpower, materials, and machines in mass production.*

Industrial production technicians prepare layouts of machinery and equipment, plan the flow of work, investigate and analyze production costs to eliminate unnecessary expense, study production methods, and determine time requirements for production operations.

6. *Advises, plans, and estimates costs as a field representative of a manufacturer or distributor of technical equipment and/or products.*

Technical sales and field representatives must have a high level of technical ability. Their functions may include making demonstrations, advising on technical details, and training personnel.

7. *Is responsible for performance or environmental tests of mechanical, hydraulic, pneumatic, electrical, or electronic components or systems and the preparation of appropriate technical reports covering the tests.*

Two elements are present in this criterion: testing and reporting. The technician's function in these two activities should include major responsibility for determining testing procedures, selecting the instrumentation to be used, designing special test equipment, and conducting the test itself. The reporting function is of equal if not greater importance, involving as it does the accurate interpretation of test results and the oral and written communication of these results.

8. *Prepares or interprets engineering drawings and sketches.*

The significant element of this criterion is the use of a broad knowledge of the materials, processes, and principles involved in engineering design rather than the skills and techniques of drafting.

9. *Selects, compiles, and uses technical information from references such as engineering standards, handbooks, and technical digests of research findings.*

These reference materials are primary sources of information for all technical personnel. The selection and use of such material is especially significant when it is a part of a wide range of responsibility that involves investigation, planning, and independent decision making.

10. *Analyzes and interprets information obtained from precision measuring and recording instruments and makes evaluations upon which technical decisions are based.*

The ability to interpret information obtained by precision measuring instruments involves an understanding of the instruments, the systems in which they operate, and the practical accuracy limits that should be expected under normal operating conditions.

11. *Analyzes and diagnoses technical problems that involve independent decisions.*

Two elements are present in this criterion: technical knowledge and judgment. The knowledge required is often described as an understanding of engineering principles, including elements of physics, chemistry, mechanics, dynamics, electricity, and their industrial applications. Judgment requires, in addition to technical know-how, substantive experience in the occupational field.

12. *Deals with a variety of technical problems involving many factors and variables which require an understanding of several technical fields.*

Versatility is a characteristic that relates to breadth of understanding, the antithesis of narrow specialization. In applying this criterion the importance of technical training in providing a broad background should be appraised. It is this educational background that provides versatility in those occupations where experience alone cannot include the wide-range knowledge required.

Applying the criteria

In applying the 12 criteria to a specific occupation, certain conditions should be observed. One of these conditions has been outlined

previously but, because it is all-important, it bears repeating. It is the absolute necessity for a reference base as represented by the five general abilities outlined at the beginning of the section. *Each of the 12 items must be interpreted within the context of this reference.* Without such a base the criteria have little value in identifying occupations for which approved preparatory technical education programs may be established.

It should also be re-emphasized that job titles will have little or no significance in selecting occupations to which these criteria are to be applied. The criteria are designed to identify occupational requirements which can be translated into educational program content. The limitations, therefore, are dictated by practical educational considerations; not by occupational titles or classifications.

Another significant aspect of the criteria is their positive approach. No attempt has been made to either exclude or include functions or activities that might be considered the special prerogatives of recognized professional or craft groups. The technician must be familiar with the work of engineers and craftsmen, since he may work with engineers at some stages and with craftsmen at others. The criteria will allow this flexibility without requiring or excluding specific occupational functions.

In the final analysis the occupational criteria and the educational program are interdependent. Neither can be correctly interpreted without a clear understanding of the other. The following sections suggest educational requirements related to these criteria and suggest some of the ways in which they can be used in the planning and promotion of technical education programs.

IV. Educational Requirements

THE EDUCATIONAL REQUIREMENTS of technical personnel have new dimensions in today's technology. Heretofore, it has been necessary, primarily because of the specialized nature of many industrial occupations, to plan and organize training programs to meet specific job requirements. Perhaps the most significant aspect of today's technology, as it relates to education, is the constantly increasing need for personnel with broad-range abilities who can shift with technological change and assume new responsibilities. This is in sharp contrast to the needs created by the industrial revolution with its emphasis on the division of labor. That era produced a generation of specialists: men and women who could and did succeed by developing a high degree of proficiency in an occupation or in one segment of a trade. Jobs and job classifications were fairly constant. The range of activities could be covered by specialized training and on-the-job experience.

The age of automation has created new occupations with new requirements and has increased the technical requirements of many existing occupations. Many of the new occupations have certain common requirements and can be grouped in broad fields of technology; some of the more clearly defined ones are: aeronautical, chemical, civil, electrical, electronics, and mechanical. There are, of course, many subdivisions. Mechanical technology, for example, may include aspects of drafting and design, machine and tool design, manufacturing processes, metallurgy, internal combustion engines, or steam power.

In the preceding section of this document the occupational requirements of a technician were given a reference base. Five universal abilities were identified as basic elements of technician occupations. These might well be called the "five imperatives of technical education." A program that is to provide the range of understanding indicated by the "five imperatives" must be highly efficient. It must, first of all, prepare the individual for an entry job in which he can be productive with minimum orientation. To progress rapidly to positions of greater responsibility he must also understand, in general, the range of jobs within his field of technology. The educational program must be specialized without overspecialization; theoretical

but not impractical; and scientific without sacrificing the learning values that come from the realistic application of scientific principles.

Maintaining a balance of these conditions with full consideration of students' capabilities, staff qualifications, and physical facility limitations, presents a real problem in the design of technical education curriculums. What are the elements of an instructional program that can meet these requirements?

The completion of a good 2-year post high school curriculum is an educational achievement level for technicians that has gained national recognition. Two Office of Education publications, *Electrical Technology* (OE-80006) and *Electronic Technology* (OE-80009)[1] are representative of such programs.

Over the years individual institutions throughout the United States and Canada have become well-known for consistent high-standard educational services in technical programs of this type. The graduate of a recognized 2-year technical program has an identifiable background. It is this educational background, apart from the institution in which it is offered, that has real significance for technical education. Secondary school programs and some of the newly developed combination secondary, post secondary programs can be best evaluated by using the content of the 2-year post high school curriculum as a reference base. Curriculum content should be essentially similar, no matter where the program is given.

In order to determine the organizational patterns of 2-year post high school technical programs, a study was made of established curriculums in institutions that have a history of successful operation. The selection of institutions and curriculums was not contingent on their being approved by any agency, and such selection does not indicate approval by the U.S. Office of Education. The information for the study was obtained from the published catalogs of the 25 institutions.

These curriculums required an average of 71 semester credit hours for completion, with 35 credit hours (49 percent of the credit) devoted to courses in the field of specialization. Mathematics requirements averaged 9 credit hours, science 9 hours, auxiliary and supporting technical courses 7 hours, and general education 11 hours. Table 1 indicates the range of requirements in these subject-matter areas. Since the number of curriculums represented in this study is limited, the range of credit requirements in each curriculum division may reflect this limitation. An analysis of this nature is always subject to errors in grouping because of disparity in course titles. The errors in this study, however, should not be significant.

[1] See References, p. 23.

Table 1.—Analysis of 32 selected technology curriculums (electrical, electronic, and mechanical) in 25 post high school institutions

Curriculum division	Credit hour requirement			
	Range		Mean	
	Minimum	Maximum	Hours	Percent of total
TOTAL	62	80	71	100
Technical specialty courses—Basic and advanced courses in the technology (e.g., machine design)	19	47	35	49
Mathematics courses—Algebra, trigonometry, analytic geometry, calculus	5	20	9	13
Science courses—Physics, chemistry, mechanics, hydraulics, thermodynamics, etc	3	22	9	13
Auxiliary and supporting technical courses—Mechanical drawing (general), shop, technical report writing	4	21	7	10
General education courses—Communications, humanities, social studies, health	2	24	11	15

This analysis was primarily quantitative and serves only to indicate the relative subject-matter emphasis in terms of credit requirements. The semester credit-hour unit was chosen as a commonly understood measure of instructional content. In the majority of the curriculums, 3 hours of laboratory study per week were required for 1 hour of credit.

Figure 1.—Curriculum Requirements in Post High School Institutions, by Credit Hour and Contact Hour

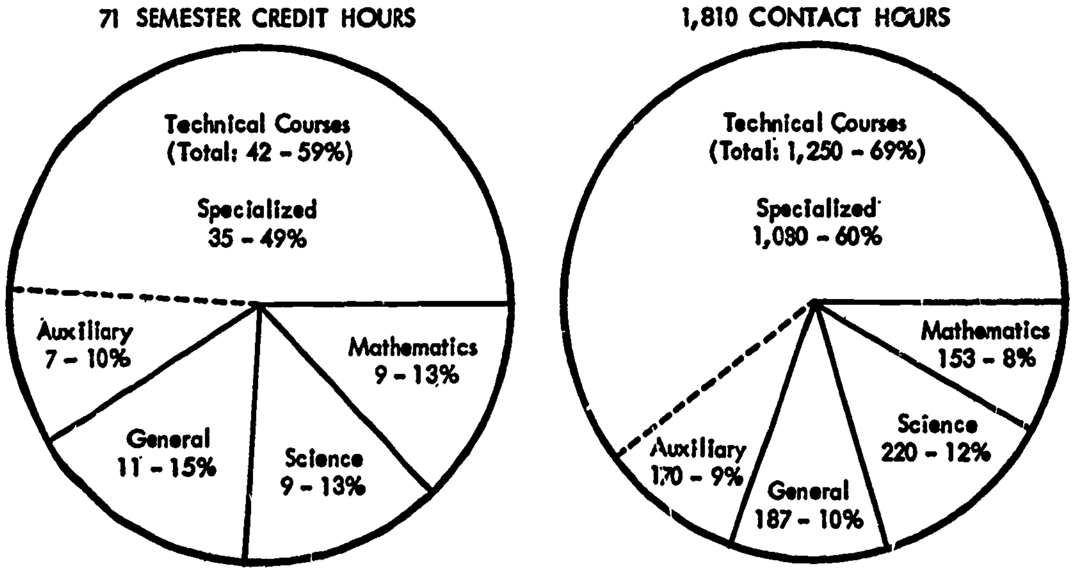

Table 2.—A sample curriculum in electronic technology showing the class, laboratory, and study time required

Course, by semester	Hours per week				Semester hours [1]
	Class	Laboratory	Study	Total	
First Year					
First semester	14	12	28	54	18
Technical mathematics I	4	0	8	12	4
Direct current circuits and machines	3	6	6	15	5
Social science	3	0	6	9	3
Technical drawing	1	6	2	9	3
Communication skills	3	0	6	9	3
Second semester	12	18	25	55	18
Technical mathematics II	4	0	8	12	4
Time varying circuits	3	6	6	15	5
Basic electronics	3	6	6	15	5
Shop processes	0	3	1	4	1
Technical report writing	1	0	2	3	1
Graphic analysis	1	3	2	6	2
Second Year					
Third semester	10	18	20	48	16
Engineering science	3	3	6	12	4
Circuit tracing	1	3	2	6	2
Special electronic circuit design and analysis	3	6	6	15	5
Transmitter theory and operation	3	6	6	15	5
Fourth semester	9	24	21	54	17
Research report (special problem)	0	6	3	9	2
Ultra-high frequencies and microwaves	3	6	6	15	5
Television circuits	3	6	6	15	5
Industrial electronics	3	6	6	15	5

[1] 1 semester=17 weeks.

The student contact hour provides another base for comparing the relative emphasis on subject matter in the curriculum. The contact hour represents one period of 50 minutes in either class or laboratory work. The mean requirement for the 32 curriculums analyzed in the study was 1,810 contact hours.

A comparison of credit-hour and contact-hour requirements is shown in figure 1. Technical courses make up 59 percent of the total credit-hour requirement in these curriculums but require 69 percent of the student's total time in attendance. This is due to the exten-

sive laboratory work necessary in technical study. Mathematics and general education courses normally do not require laboratory work, and science laboratory requirements are not as time-consuming as those of technical courses.

The subject-matter grouping in this analysis was chosen to simplify, as much as possible, the problem of identifying individual courses by the information found in catalogs. Five groups were used: technical specialty courses, mathematics courses, science courses, auxiliary and supporting technical courses, and general education courses.

While this grouping may appear to be oversimplified, it has certain advantages over a more detailed breakdown. It becomes extremely difficult to classify some courses from catalog descriptions if a more sophisticated classification system is used. Even with the five groups used here, problems may arise in making distinctions, for example, between technical speciality courses and supporting technical courses. Problems arise also in classifying so-called "applied" courses in mathematics and science. This method of subject-matter classification as it applies to a particular curriculum is shown in table 3.

A consistent curriculum pattern appears in the proportion of time devoted to class, laboratory, and outside study. It is common practice to require approximately two hours of outside study for each hour of scheduled class attendance. Normally, some outside work is also required for laboratory data preparation, report writing, calculation, etc. Where class and laboratory work are closely correlated, however, the requirements for class preparation can be reduced proportionately to provide time for the laboratory requirements. A rule of thumb can then be used: 2 hours of study time for each scheduled class period. The electronic technology curriculum shown in table 2 illustrates a good balance in time requirements. The first semester of this curriculum requires 26 hours per week of class and laboratory attendance, and a typical student work schedule for the semester might break down as follows: class time 14 hours, laboratory time 12 hours, and outside study time 28 hours. This represents a total workload of 54 hours per week, not excessive in curriculums of this type. Much of the responsibility for this work schedule is placed on the student. To facilitate time budgeting, most curriculums do not schedule, in any one term, more than 5 subjects requiring extensive outside preparation.

Another characteristic of technical curriculums is the correlation of mathematics and physical sciences with technical study. This is usually accomplished by a concurrent scheduling of these courses in the first two terms and by planning the technical course work to parallel the student's progress in mathematics and science. The latter

involves much detailed planning and careful scheduling. Instructional material for the specialized courses must be tailored to introduce, in proper sequence, technical concepts that may be substantiated by mathematical and scientific proof.

Table 3.—A sample curriculum in electrical technology showing the classification of courses, by curriculum division

Course, by semester	Curriculum division [1]	Time and credit distribution		
		Class hours	Laboratory hours	Credit
FIRST YEAR				
First semester		14	12	18
Technical mathematics I (algebra and trigonometry)	M	4	0	4
Direct current circuits and machines	Sp	3	6	5
Social science	G	3	0	3
Technical drawing	A	1	6	3
Communications skills	G	3	0	3
Second semester		12	18	18
Technical mathematics II (applied analytical geometry and calculus)	M	4	0	4
Time varying circuits	Sp	3	6	5
Basic electronics	Sp	3	6	5
Shop processes	A	0	3	1
Technical report writing	A	1	0	1
Graphic analysis	A	1	3	2
SECOND YEAR				
Third semester		12	15	17
Engineering science	Sc	3	3	4
Electrical instruments and measurements	Sp	2	3	3
Alternating current machines	Sp	3	6	5
Electrical installation planning	Sp	2	0	2
Chemistry and applications in electricity	Sc	2	3	3
Fourth semester		11	15	16
Industrial electronics	Sp	3	3	4
Electrical control circuits	Sp	3	3	4
Electrical power systems-in-plant (with utility systems option)	Sp	3	3	4
Operating problem analysis	Sp	2	6	4

[1] Curriculum divisions.

A—Auxiliary or supporting technical courses
G—General courses
M—Mathematics courses
Sc—Science courses
Sp—Technical specialized courses

One of the advantages of this approach is that specialized course work may be introduced in the first term. This makes possible a greater ultimate depth of penetration in the technical specialty. Introducing basic elements of the technical specialty during the first stages of the program provides more time in the final stages for the more complex technical subjects that include systems analysis, design, and individual problem assignments.

Another distinct advantage of this system is the increased student interest and motivation that is generated. The student is immediately introduced to the more interesting technical subjects. He can also develop an early appreciation of the values of mathematical analysis in technical study—a respect for the inherent "honesty" of mathematics.

Some confusion exists as to the basic differences between a 2-year technical program and the first two years of an engineering program. It is helpful in making this distinction to compare the relative emphasis on subject matter in these two programs as shown by table 4.

The two curriculums shown in the table were taken from the same catalog and are offered by an institution that has conducted both engineering and technical education services for many years. While this comparison represents only one curriculum in each of the two fields of study, it does serve to indicate the basic difference between these two specific types of curriculums. In the technical curriculum 47 percent of the course work is devoted to the field of specialization while in the first two years of the engineering curriculum only 6 percent is "specialized." The engineering curriculum is arranged to provide extensive study in mathematics and science (68 percent) while the technical curriculum devotes 27 percent of the 2-year period to these disciplines. However, in the technical curriculum, a substantial part of the technical course work is devoted to mathematical analysis and to applications of the physical sciences.

Table 4.—Comparison of semester hours for a 2-year (68 semester hour) technical education program and the first 2 years of an engineering degree curriculum [1]

Course	2-year mechanical technology program	First 2 years of mechanical engineering
TOTAL	68	68
Specialized technical courses	32	4
Mathematics and science	18	46
Auxiliary and supporting technical courses	8	2
General education courses	10	16

[1] Exclusive of military science.

Being complete in itself, the technical program is distinctly functional. The 32 semester hours of specialized course work clearly identify the objective of the curriculum as being employment-oriented rather than general or pre-engineering in nature. This objective has not been compromised to meet transfer credit requirements.

Technical education programs have been operated successfully in three types of secondary schools: technical high schools, vocational high schools, and comprehensive high schools.

Although there are important differences between the high school and the post high school programs, the occupational criteria and the educational standards outlined in this document can be helpful in planning and evaluating high school technical education programs. Such factors as depth of understanding in a technology and ability in mathematical and scientific analysis are common to all good technical programs. They are determined by job requirements, not by grade levels or school organization patterns.

The appendix illustrates the division of subject matter in a 3-year technical curriculum offered at the secondary school level.

V. Effective Use of This Bulletin

THE CRITERIA outlined in this bulletin were developed to identify occupations that require intensive technical training. The five general abilities that were used to establish the level of these occupations constitute an education standard. By this standard, the technician should have an educational background equivalent to that obtained in a program of at least 1,800 hours of instruction, with a pattern of course work comparable to that found in the 32 full-time post high school programs shown in table 1.

The qualitative standards outlined in this bulletin should be valuable to the vocational education administrator in informing and instructing various individuals and groups concerned with the establishment of technical education programs. State and local supervisors need to understand the criteria and curriculum patterns and where and how this information can be used. It can be especially useful in working with:

1. Advisory committees
2. Industrial and educational consultants
3. Officials of Federal, State, and local governments
4. Labor-industry groups
5. Curriculum committees
6. School guidance personnel
7. Professional associations
8. Parents and students
9. Employers
10. Accrediting associations.

Apart from his industrial experiences, necessary as these are to the development of productive ability, the technician has certain specific educational requirements. Throughout this document the emphasis has been on identifying those requirements that can best be provided by programed instruction. He may reach this required level of understanding in a number of ways, of which the formal 2-year post high school program is only one. There will, of course, be grades and levels of training programs as well as grades and levels of individual ability. There will be secondary school programs, part-time evening courses, and extension courses all within the several fields of technology. Also, individuals may advance to technical positions through experience and self-improvement.

Although the requisite proficiency for technical occupations can be obtained in a number of ways, the 2-year technology curriculum serves as a reference base for identifying technicians who work in these occupations. Such a reference is badly needed to promote understanding and support for technical education. It is extremely awkward and patently unnecessary to describe a job in order to identify an individual's occupational field. The technician, whatever his immediate functions and responsibilities may be, should be thought of as an individual with a distinctive educational background.

The information contained in this bulletin can be helpful in promoting a better understanding of technician occupations and technical education. It can be used in the following activities.

Program planning and development

A primary use for occupational and educational criteria is to establish sound objectives for training programs. National needs are more significant than local needs in determining these objectives. The critical national need is for persons with well-defined abilities in established fields of technology. The training requirements for these persons must also be well defined.

The criteria outlined in this document are based on analyses that are national in scope. They emphasize ability and knowledge common to many jobs within a technology and are oriented toward national rather than local needs. There is no reason to believe, however, that national and local needs are in any way incompatible where the training of technicians is concerned, particularly in view of the broad technology-based objectives of this training. The requirements for success as an electronic technician, for example, would appear to be substantially the same in all fields of electronic technology and would not vary greatly from one locality to another.

Selecting occupations to be studied in making surveys

Industrial surveys to determine technical training needs must, of necessity, identify the occupations for which this training is to be offered. The accuracy and reliability of the terms and conditions used to delineate the occupational areas to be studied will determine the accuracy and validity of the survey results. Failure to define the occupations accurately can destroy the usefulness of the survey in planning educational services. The five universal ability requirements described in this document will provide a more uniform basis for occupational studies. In a sense, they represent specifications

that must be met before the 12 specific occupational criteria can be used effectively in identifying occupations for which technical training is required.

The criteria, when used to prescribe limits for the occupations to be studied, should be thoroughly understood by those responsible for the survey. This will necessitate a planned training program for survey personnel which should include a trial run, applying the criteria to selected occupations. Industrial representatives who participate in the survey should also be well oriented in the use of the criteria.

Identifying occupational areas as distinguished from technician "jobs"

The development of technical education has been hampered by a lack of uniform occupational terminology. In some industrial organizations technical jobs have engineering classifications; in some there are well defined technician classifications; still others use the title indiscriminately. Because of this disparity it has been extremely difficult to identify the occupational needs of persons who can best be given preparatory training in a technical education program.

The occupational criteria presented in this document can be used to identify occupations on the basis of functions that require broad-range abilities. These criteria can reduce the possibility of gearing preparatory programs to needs that are not representative of technician occupations.

Identifying broad national as well as specific local needs

Meeting the needs of local industries has traditionally been a cornerstone of vocational education. Technical education offers possibilities for broad basic training that will meet both national and local needs.

Where the training requirements for locally prevalent occupations meet the criteria, there are many ways in which a close cooperative relationship between the technical school and the industry can be of mutual advantage. By the same reasoning, however, if specific local training needs are for occupations that do not meet the criteria, preparatory training for these needs should be referred to other vocational education services.

Purely local training needs should not pre-empt the development of technical programs with wide-range national objectives. To illustrate, it would not be effective technical education to give excessive emphasis to machine shop practice in a mechanical technology curricu-

lum at the expense of instruction in metallurgy, heat treating, or machine design; particularly if this was being done to satisfy a purely local need of manufacturing industries.

The primary concern in any educational program is for the student. It is vital, especially in preparatory programs, that his preparation should be broad in order not to impose unnecessary limits on his ability to advance in the technological field of his choice.

Determining the appropriate emphasis on specialized study in curriculum design

The criteria can be used to direct curricular emphasis toward preparation for job responsibilities that require judgment and decision-making and away from routine job functions. An understanding of the balance between these two factors is needed to determine the optimum amount of specialization in technical curriculums. Overspecialization can result where the first factor is overlooked or misunderstood.

Undue specialization appears where one element of the technology is given excessive time in the curriculum. Welding processes, for example, are an important part of some programs in mechanical technology. It would be overspecialization, however, to devote so much time to the development of skills in welding that valuable curriculum elements such as metallurgy, heat treatment, or fixture design are sacrificed.

The criteria, properly applied, will help to identify and indicate the relative importance of the elements that should be included in a technical education program.

Public relations

As technical education becomes established in the public view as a distinct form of education, the image created will be the result of the cumulative effort made in this area. The criteria can be used to good advantage to illustrate the level of instruction required. They identify educational program objectives in terms of occupational needs.

School counselors should find the criteria helpful in interpreting technician job descriptions in terms of the preparation required for students interested in these occupations. School officials, using the criteria, can give concrete answers to parents who are concerned with the types of education needed for today's and tomorrow's technology. State and local administrators who represent technical education

services should find the criteria valuable as a basic reference in meetings, conferences, and various phases of program development.

The occupational and educational criteria suggested in this publication represent only one step in developing standards of quality for technical education. Many equally significant factors should be analyzed: organization of courses and instructional processes to coordinate classroom and laboratory work; instructional staff competencies; optimum proportions of theory and application in technical study; teaching of mathematics by application as contrasted with the traditional unit-course approach; and similar elements of the total curriculum.

Finally, a system of program evaluation should be developed. Technical education programs cannot operate as isolated islands of learning, independent of each other, and at the same time substantially influence the total national movement in this field of education. An objective evaluation by experienced persons is a form of cross-fertilization that provides an excellent means to program improvement. A nationwide program of evaluation, planned and conducted by experienced technical education personnel, would do a great deal to promote the understanding and support that will be needed in the years ahead.

References

AMERICAN SOCIETY FOR ENGINEERING EDUCATION, Technical Institute Division. *Committee Report on Curriculum Development.* New York: McGraw-Hill Book Co., 1958. (Special Issue, Technical Education News, 18:1, 1958)

ENGINEERS COUNCIL FOR PROFESSIONAL DEVELOPMENT. *Accredited Technical Institute Programs in the United States, 1959.* (Reprint from Twenty-seventh Annual Report.) New York: the Council (29 West 39th St.). 8 p.

HENNINGER, G. ROSS. *The Technical Institute in America.* New York: McGraw-Hill Book Co., Inc., 1959. 176 p.

SMITH, LEO F. and LIPSETT, LAURENCE. *The Technical Institute.* New York: McGraw-Hill Book Co., Inc., 1956. 319 p.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, Office of Education. *An Annotated Bibliography of Surveys and Studies in Vocational-Technical Department Education.* Washington: the, 1961. 12 p.

———. *Determining Requirements for Development of Technical Abilities Through Extension Courses.* Washington: U.S. Government Printing Office, 1961. 14 p. (OE–80010)

———. *Electrical and Electronic Technology.* Job Descriptions and Suggested Techniques for Determining Courses of Study in Vocational Education Programs. Washington: U.S. Government Printing Office, 1960. 34 p. (OE–80004)

———. *Electrical Technology:* A Suggested 2-Year Post High School Curriculum. Washington: U.S. Government Printing Office, 1960. 118 p. (OE–80006)

———. *Electronic Technology:* A Suggested 2-Year Post High School Curriculum. Washington: U.S. Government Printing Office, 1960. 97 p. (OE–80009)

———. *Mechanical Drafting and Design Technology:* Job Descriptions and Suggested Techniques for Determining Courses of Study in Vocational Education Programs. Washington: U.S. Government Printing Office, 1960. 26 p. (OE–80000)

———. *Mechanical Technology, Design and Production.* Suggested Techniques for Determining Courses of Study in Vocational Education Programs. Washington: U.S. Government Printing Office, 1962. 29 p. (OE–80014)

U.S. DEPARTMENT OF LABOR, Bureau of Employment Security. *Technical Occupations in Research Design and Development.* (Considered directly supporting to engineers and physical scientists.) Washington: U.S. Government Printing Office, 1961. 66 p.

———, Bureau of Labor Statistics. *Scientific and Technical Personnel in American Industry.* (Report on a 1959 Survey, National Science Foundation.) Washington: U.S. Government Printing Office, 1960. 66 p.

WICKENDON, WILLIAM E., and SPAHR, ROBERT H. *A Study of Technical Institutes.* Lancaster, Pa.: Society for the Promotion of Engineering Education, 1931.

WOOD, HERBERT S. *A Study of Technical Education in California.* Sacramento, Calif.: Bulletin of the California State Department of Education, Vol. 29, No. 7, September 1959. 122 p.

Appendix

A 3-Year High School Mechanical Technology Curriculum

TECHNICAL EDUCATION programs conducted in secondary schools have certain identifiable characteristics. These programs are designed for selected students whose interests and aptitudes have been clearly defined. Only those students who have demonstrated high aptitude in mathematics and science can reasonably be expected to make satisfactory progress in such programs. Because of the rigorous requirements for outside study, a high degree of interest is also required.

The high school curriculum normally contains two basic elements: (*a*) general education to provide at least the minimum requirements for college admission, and (*b*) technical course work designed to give the student a foundation preparation for a technical occupation. The curriculum requires a 3-year program, a 7- or 8-period school day, and a student work load of 40 to 50 hours per week, including approximately 15 hours of homework.

The school population is a significant factor in the success of a high school technical education program. Because of the special nature of technical education, the number of students who are both interested in and qualified for the program is usually only a small percentage of the school-age group. In general then, these programs have been most successful in large school systems and particularly in schools that provide an area service for several school districts.

The following is the type of mechanical technology curriculum currently offered in a comprehensive high school. This type of curriculum involves 1,350 hours of technical course work, 810 hours of mathematics and science, and 1,080 hours of general education. High school programs will, of necessity, devote more time to mathematics, science, and general education courses than post high school programs. However, the technical course content of the two programs does provide a basis for comparison. The 1,350-hour requirement for technical study in the high school curriculum shown here compares favorably with the 1,328-hour mean for the post high school programs.

Sample 3-Year High School Mechanical Technology Curriculum

Course,[1] by grade	*Periods per week*	*Contact hours per week*
Tenth grade		
English	5	3.75
Mathematics	5	3.75
Mechanical drawing	10	7.50
Machine shop theory and practice	10	7.50
Elective	5	3.75
Health	5	3.75
Eleventh grade		
English	5	3.75
World history	5	3.75
Mathematics	5	3.75
Chemistry	5	3.75
Mechanical drawing	10	7.50
Machine shop theory and practice	5	3.75
Strength of materials	5	3.75
Twelfth grade		
English	5	3.75
American history	5	3.75
Mathematics	5	3.75
Technical physics	10	7.50
Metallurgy	5	3.75
Machine design	5	3.75
Elective	5	3.75

[1] 45-minute periods, 36-week semesters:

	Contact hours
Technical courses	1,350
Mathematics	405
Science	405
General education	1,080
TOTAL	3,240

U.S. GOVERNMENT PRINTING OFFICE: 1965 O—782-517